INDOOR AIR QUALITY ASSESSMENT

Shaker Lane School
35 Shaker Lane
Littleton, MA 01460

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Matthew J. Lucey, Director of Business and Technology for Littleton Public Schools (LPS), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at the Shaker Lane School (SLS) in Littleton, Massachusetts. The request was prompted by concerns of water damage and possible mold growth in carpeting that reportedly may have resulted from a plumbing leak that occurred in a classroom. On January 12, 2006, a visit to conduct an assessment of the school was made by Cory Holmes, Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Mr. William Meagher, Director of Maintenance, LPS, during the assessment.

The SLS is a two-story, brick on cement slab building originally constructed in 1960. Additions were made in 1971 and in 1998. Renovations were made to the 1960 and 1971 portions of the building in 1998. Although these renovations included new electrical components, windows, carpeting/floor tile and new boiler, they did not include replacement of mechanical ventilation equipment.

The first floor consists of general classrooms, special education rooms, computer room, library, the school nurse's office, cafeteria/kitchen, teachers' room, art room, gymnasium and office space. The second floor contains general classrooms and conference rooms. Windows throughout the building are openable. Selected areas are provided with air conditioning (i.e., library, computer rooms and offices).

As mentioned previously, water damage/mold concerns resulting from a plumbing leak in classroom 104 was reported as the primary reason the MPDH was asked for assistance. Floor covering in classrooms in this section of the building is composed of 80% carpeting and 20% tile (Picture 1); the carpeting is adhered directly on the cement slab (i.e., no backing/padding exists). Mr. Mahar reported that a heating pipe in classroom 104 broke on December 14, 2005, during the hours of school operation. Later that day, a carpet cleaning company was hired to extract the standing water and clean the carpeting, while the maintenance department attempted to turn off the valve to the heating pipe. Mr. Mahar reported that the carpet was found wet the following day due to continual leaks. The leaking continued for several days, until December 20, 2005 when a licensed plumber was able to locate and secure the valve, which was installed behind the heating unit. Mr. Mahar reported that although the leaking was continual, school maintenance staff extracted water from the carpet to prevent the water from becoming stagnant or a source for mold growth. Once the leak was repaired, the cleaning company was again contracted to extract water, shampoo and deodorize the carpet. The carpet was also mechanically dried with fans and heat to speed drying. The classroom has not been occupied since the water damage occurred.

Methods

MDPH staff performed a visual inspection of building materials in classroom 104 to assess water damage and/or microbial growth. Moisture content of carpeting and materials prone to moistening (e.g., shelving, wooden baseboard) was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe. Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor

Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using an Hnu, Model 102 Snap-on Photo Ionization Detector (PID).

Results

This school houses approximately 470 students in grades pre-K through 2, with approximately 75 staff members. Tests were taken during normal operations at the school, with the exception of 104, which was unoccupied due to remediation efforts. General IAQ testing results appear in Table 1, results of moisture testing are included as Table 2.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in four of fifteen areas, indicating adequate ventilation in the majority of areas surveyed. However, a few areas were empty or sparsely populated at the time of the assessment. Low occupancy can greatly reduce carbon dioxide levels. Therefore, carbon dioxide levels would be expected to be higher with increased occupancy.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (Picture 2). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a diffuser located on the top of the unit. Adjustable louvers control the ratio of fresh and recirculated air. Obstructions to airflow, such as furniture located in front of and/or materials stored on univents, were observed in some areas (Picture 3), despite labels restricting placement of objects on heating units per order of the fire department (Picture 4). In order for univents to provide fresh air as designed, these units must remain free of obstructions. In addition, univents in the 1960 and 1971 portions of the building are reportedly original equipment, 35 to 45 years old. Univents of this age are difficult to maintain because replacement parts are often unavailable.

The mechanical exhaust ventilation system in classrooms consists of wall or ceiling-mounted vents connected to rooftop fans (Pictures 5 and 6). The system was operating in most areas during the assessment. At the time of assessment, the exhaust motor that services the section housing classrooms 103, 104 and 105 was deactivated, reportedly due to a broken fan belt on order for repair. Without functioning exhaust ventilation, odors and other environmental pollutants can build up due to lack of air exchange. Exhaust vents were also found obstructed by furniture, boxes and other items during the assessment (Pictures 7 and 8). It is also important to note that the location of some exhaust vents can limit exhaust efficiency. In some classrooms, exhaust vents are located above hallway doors (Picture 9). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from the classroom.

Common areas throughout the building (cafeteria, gymnasium, library) have ventilation provided by air handling units (AHUs). Fresh heated/cooled air is supplied through ceiling mounted air diffusers and ducted back to the AHUs via return vents. These systems were all operating during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The systems were reportedly balanced during the 1998 renovations.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 68^{o} F to 74^{o} F, which were within the MDPH recommended comfort range in all but one area. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents obstructed, exhaust vents obstructed/deactivated).

The relative humidity measured in the building ranged from 31 to 38 percent, which is below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. As previously discussed, the source of moisture was a plumbing leak in classroom 104. Identification of building materials with increased moisture content over normal concentrations may indicate a possible source for mold growth. In an effort to ascertain moisture content of building materials in classroom 104 moisture readings were taken in areas that were most likely impacted by exposure to moisture (i.e., directly in the path of the leak). Building materials tested include fixed carpeting, area carpets, wooden baseboard and the bottom of wooden shelves that were resting on carpeting in this area (Pictures 10 and 11). For comparison, moisture measurements in *non-effected* carpeting were taken in classroom 104; moisture measurements were also taken in adjacent classrooms 103 and 105.

As indicated, moisture content was measured with a Delmhorst Moisture Detector equipped with a Delmhorst Standard Probe. The Delmhorst probe is equipped with three lights that function as visual aids that indicate moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. All materials tested were found to have low (i.e., normal) moisture content (Table 2) at the time of the assessment.

In addition, MDPH staff conducted a thorough visual examination of materials in classroom 104. Materials examined include areas beneath damaged carpeting (which required the removal of carpeting in the area) (Pictures 12 and 13), as well as shelving, area carpeting, wooden baseboard, walls and furniture. No visible mold growth or associated odors were observed and/or detected during the assessment.

Although no evidence of mold growth related to the plumbing leak was detected/observed, other sources of potential mold growth were observed. Several water damaged ceiling tiles were observed in classroom 104 (Picture 14). Hallways and classrooms in other portions of the building also had water damaged ceiling tiles (Table 1). Water damaged ceiling tiles in the library were reported to be a result of condensation from the air conditioning system. Water damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Spaces between the sink countertop and backsplash were observed in several classrooms (Picture 15/Table 1). Improper drainage or sink overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Repeated water damage to porous building materials (e.g., wallboard, ceiling tiles, carpet) can result in microbial growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. In this case, although the carpeting could not be dried due to a continual water leak, actions taken by the LPS maintenance department to routinely extract water from carpeting in classroom 104 over the period of December 14 to December 20, 2005 prevented water from becoming stagnant, thus preventing mold from colonizing in carpeting.

Lastly, plants were observed in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. For the SLS, indoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured outside the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 12 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 7 to 18 $\mu g/m^3$, which were below the NAAQS PM2.5 level of 65 $\mu g/m^3$ in all areas surveyed. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner; and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of VOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found on countertops and beneath sinks in a number of classrooms (Picture 16). Cleaning products contain VOCs and other chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 17). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause TVOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Several other conditions that can affect indoor air quality were noted during the assessment. In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

A number of exhaust vents and personal fans in classrooms had accumulated dust (Pictures 18 and 19). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. Dust particles can also be aerosolized when fans are activated. Dust can be irritating to eyes, nose and respiratory tract.

Exposed fiberglass insulation around pipes and open utility holes were observed in the gymnasium (Picture 20). Fiberglass insulation can be a source of skin, eye and respiratory irritation to sensitive individuals. Open utility holes can serve as a means for odors, dusts and particulates to migrate between rooms and floors.

Lastly, missing ceiling tiles were observed in a number of areas (Picture 21). Missing/ajar ceiling tiles can provide a pathway for movement of materials (e.g. odors, dust, particulate) from unoccupied areas to occupied areas. Missing ceiling tiles should be replaced flush to ceiling system to prevent such movement.

Conclusions/Recommendations

At the time of the MDPH assessment, remediation of water damaged materials was completed and deemed effective in preventing mold growth in the affected classroom. In view of the findings at the time of the assessment, the following recommendations are made:

1. Continue with plans to repair rooftop exhaust motors.
2. Remove all blockages from univents and exhaust vents.
3. Continue to operate both supply and exhaust ventilation continuously during periods of school occupancy. To maximize air exchange keep classroom doors shut.
4. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
5. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Ensure roof and/or plumbing leaks are repaired, and replace any remaining water-stained. Examine the space above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
8. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard.
9. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary. Move plants away from univents in classrooms.
10. Store cleaning products properly and out of reach of students.
11. Clean univent air diffusers and exhaust vents periodically of accumulated dust.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Seal breaches around utility holes (Picture 20) and replace missing ceiling tiles (Picture 21) to prevent the migration of odors, dust and particulate matter between areas.

14. Consider discontinuing the use of tennis balls on chair legs to prevent latex dust generation. Alternative "glides" can commonly be purchased from office supply stores; see Picture 22 for an example.

15. Refer to "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001) for more information on mold and/or remediation measures. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

16. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

17. Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

The following **long-term measure** should be considered:

1. Contact an HVAC engineering firm for an assessment of the mechanical ventilation systems (e.g., controls, air intake louvers, thermostats) in the 1960 and 1971 portions of the building. Based on the age, physical deterioration and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of repairing/replacing the equipment.

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Picture 1

Long View of Classroom 104 Showing Floor Covering; 80% Carpet 20% Tile, Note Univent against Rear Wall Where Leak Occurred

Picture 2

Modern Univent in 1998 Section of Building

Picture 3

Classroom Materials up against front of Classroom Univent Where Return Vent is Located (Bottom Front)

Picture 4

Gloves Drying on Univent Despite Label Instructing Not to Place Objects on or Near Heating Unit per Order of Fire Dept

Picture 5

Ceiling-Mounted Exhaust Vent

Picture 6

Wall-Mounted Exhaust Vent

Picture 7

Wall-Mounted Exhaust Vent Entirely Blocked by File Cabinet, Cabinet Pulled Away for Photo Op by MDPH Staff

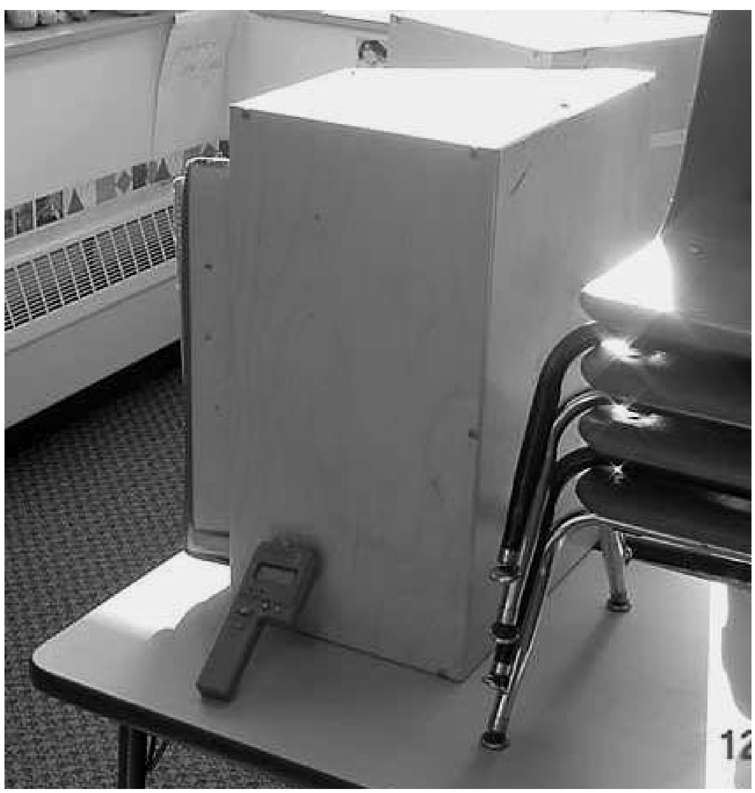
Picture 8

Wall-Mounted Exhaust Vent Partially Obstructed by Boxes

Picture 9

Proximity of Wall-Mounted Exhaust Vent to Open Hallway Door

Picture 10



Moisture Testing of the Bottom of Wooden Shelves in Contact With Carpeting

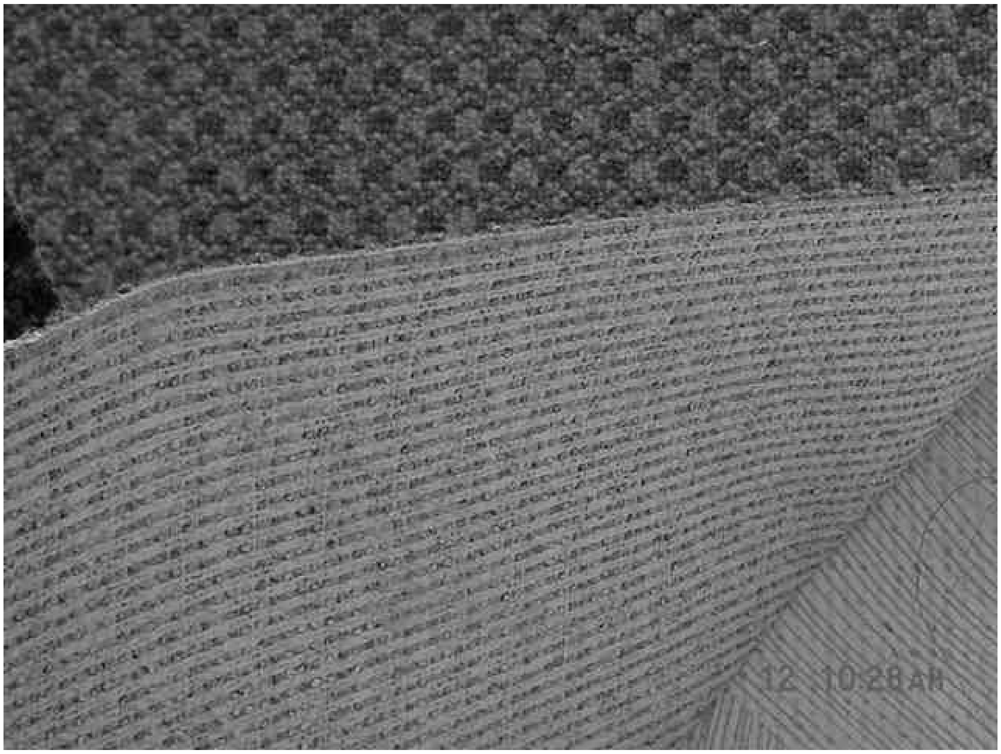
Picture 11

Moisture Testing of the Wooden Baseboard in Contact With Carpeting, Note Water Stain on Baseboard

Picture 12

Carpeting Removed in Classroom 104, Note no Padding or Backing, Dark Stains on Cement Slab Indicate Adhesive Application

Picture 13



Close-Up of Back of Carpeting in Classroom 104

Picture 14

Water Damaged/Bulging Ceiling Tiles in Classroom 104

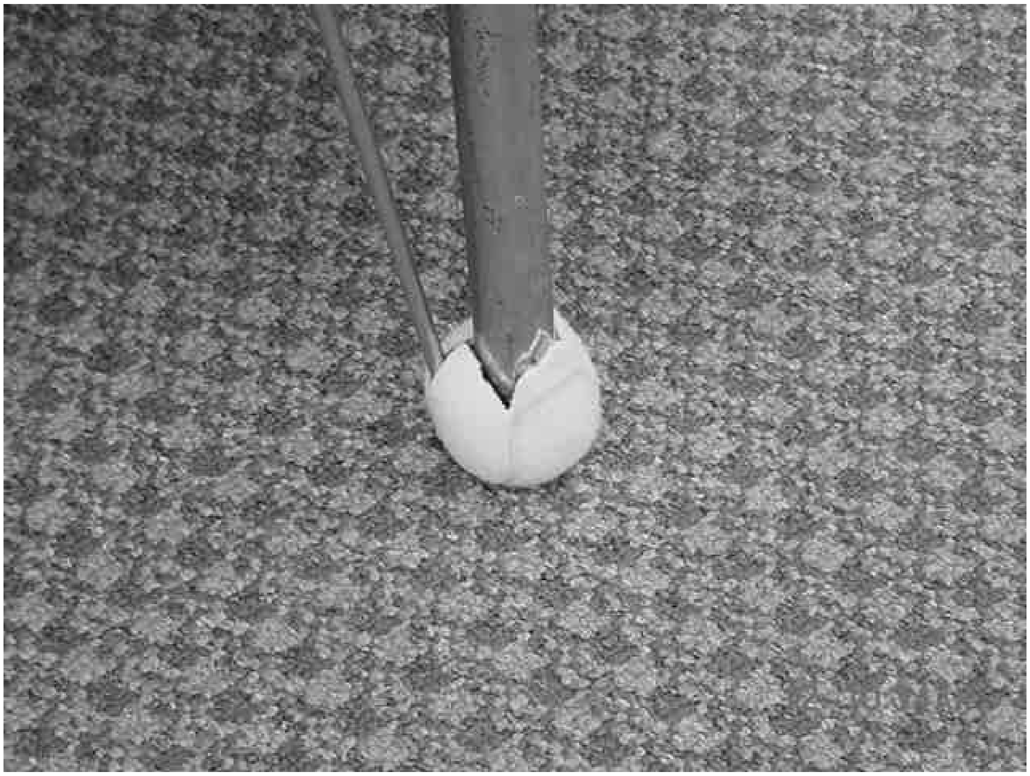
Picture 15

Spaces between Backsplash and Sink Countertop in Classroom 104

Picture 16

Spray Cleaning Products on Countertop in Classroom

Picture 17

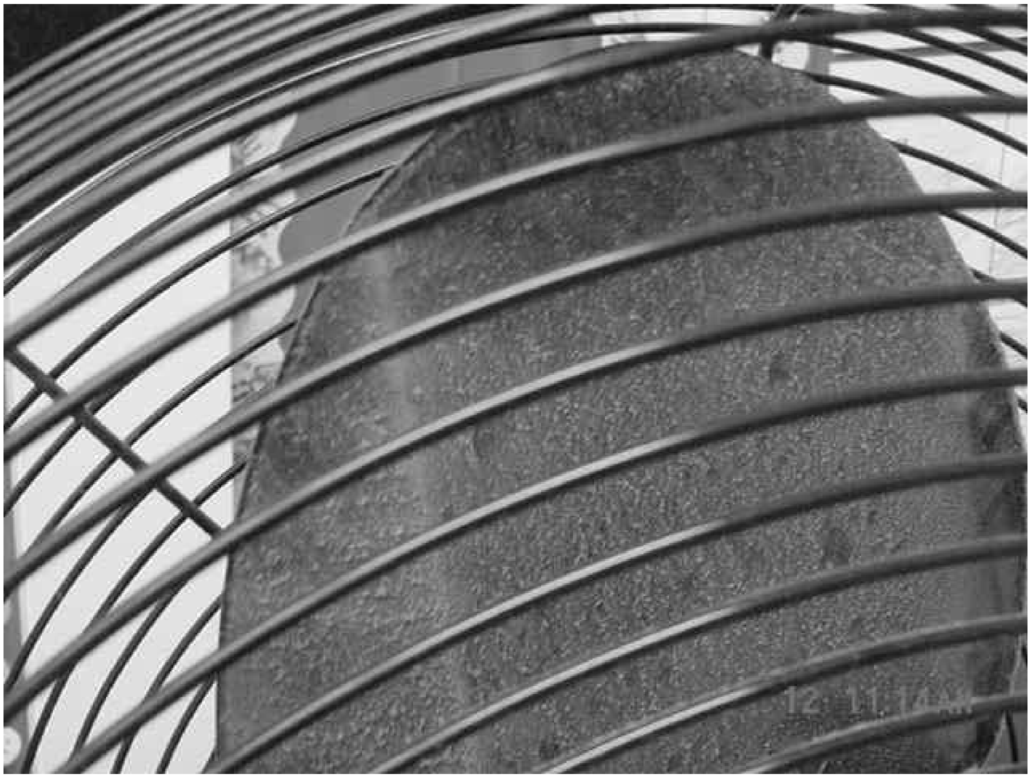


Tennis Ball on Table Leg in Classroom

Picture 18

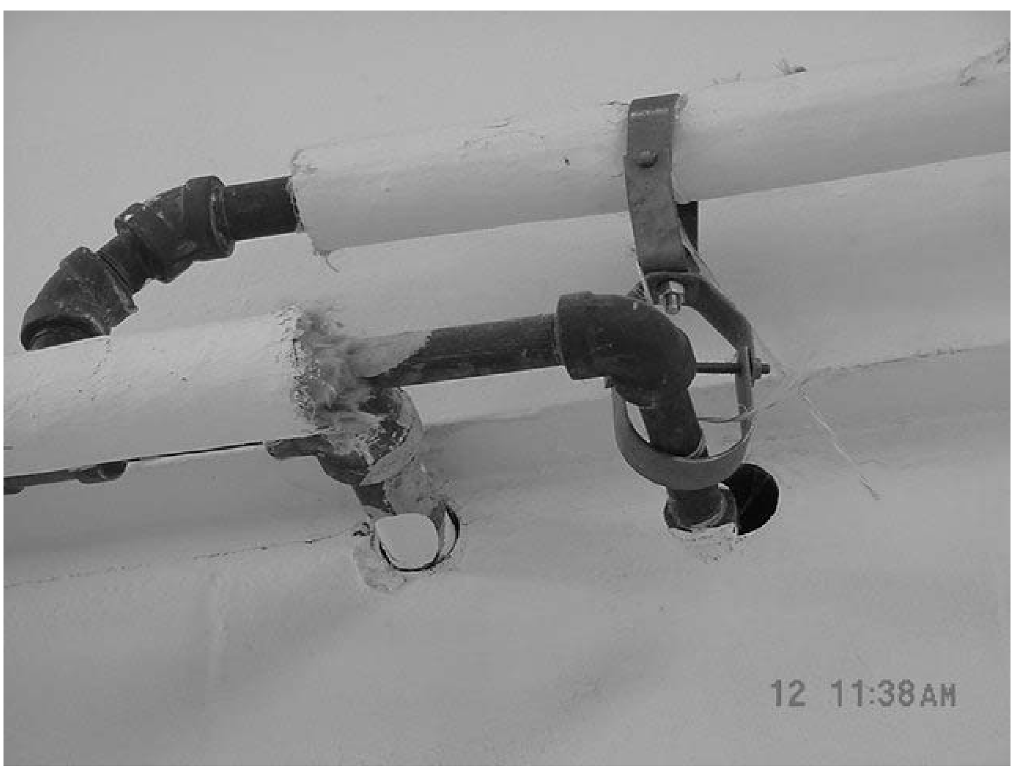
Accumulated Dust/Debris on Classroom Exhaust Vent

Picture 19



Accumulated Dust on Fan Blade in Classroom

Picture 20

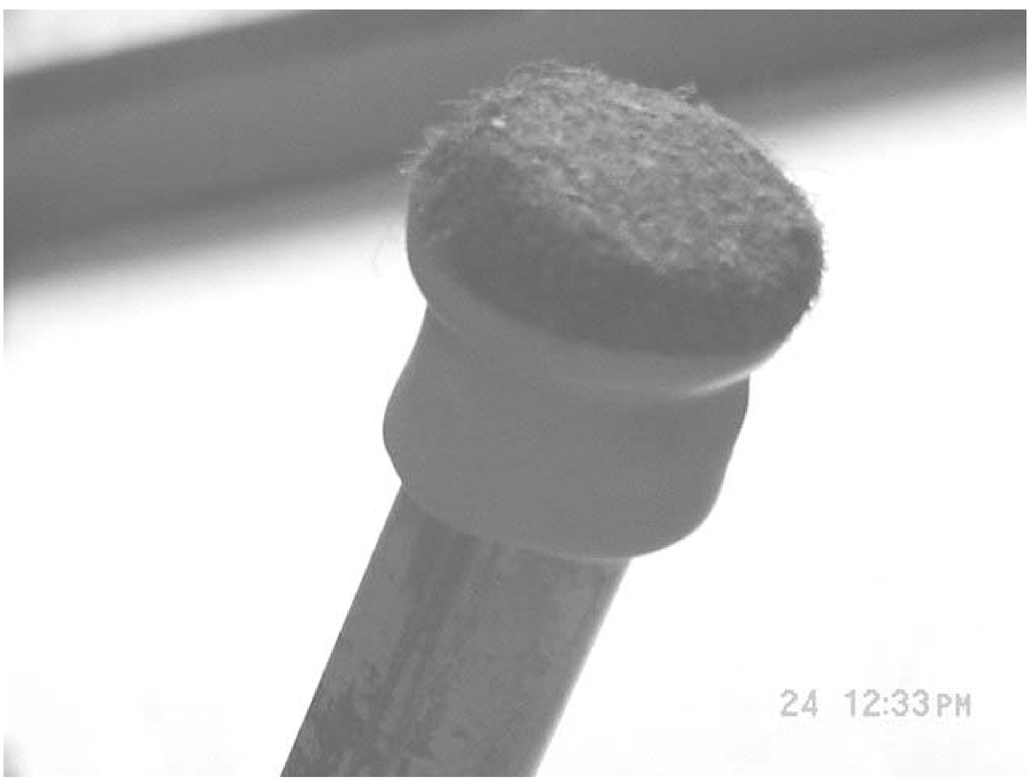


Exposed Fiberglass and Open Utility Holes in Gymnasium

Picture 21

Missing Ceiling Tiles in Classroom 210

Picture 22



"Glides" for Chair Legs that can be used as an Alternative to Tennis Balls

Shaker Lane School **Indoor Air Results**

35 Shaker Lane, Littleton, MA 01460 **Date: 1/12/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		48	45	388	ND	ND	12				mostly sunny, mild, west winds 5-10 mph .
104	0	70	38	538	ND	ND	7	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	#WD-CT: 5, breach sink/counter, plants, broken fan belt on exhaust motor-on repair list, room unoccupied due to remediation efforts.
103	15	70	34	860	ND	ND	8	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, broken fan belt on exhaust motor-on repair list, room unoccupied due to remediation efforts.
105	7	72	35	711	ND	ND	10	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, aqua/terra.
library	4	68	36	580	ND	ND	9	Y # open: 0 # total: 4	Y ceiling	Y ceiling	#WD-CT: 9, #MT/AT: 1.
110	22	71	36	694	ND	ND	14	N	Y univent	furniture	DEM, PF, cleaners.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Shaker Lane School | **Indoor Air Results**

35 Shaker Lane, Littleton, MA 01460

Table 1

Date: 1/12/2006

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
111	3	70	34	666	ND	ND	12	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, breach sink/counter, DEM, cleaners, plants.
112	23	71	34	770	ND	ND	16	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, DEM, PF, cleaners.
108	22	71	34	856	ND	ND	14	Y # open: 0 # total: 4	Y univent furniture	Y	DEM, PF, items.
202	18	71	34	673	ND	ND	13	Y # open: 0 # total: 4	Y univent items furniture	Y wall furniture	DEM, cleaners, plants.
205	20	70	33	773	ND	ND	17	Y # open: 0 # total: 4	Y univent	Y wall	DEM.
210	6	74	31	773	ND	ND	18	Y # open: 0 # total: 4	Y univent	Y wall	Hallway DO, PF, items.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Shaker Lane School

35 Shaker Lane, Littleton, MA 01460

Table 1

Indoor Air Results

Date: 1/12/2006

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
213 art	28	71	33	1006	ND	ND	15	Y # open: 0 # total: 4	Y univent	Y wall boxes dust/debris	Hallway DO,
212	21	71	35	1007	ND	ND	12	Y # open: 0 # total: 4	Y univent items furniture	Y wall location	Hallway DO, aqua/terra, cleaners, gloves drying on UV.
gym	30	73	32	668	ND	ND	10	N	Y ceiling	Y wall	exposed fiberglass on pipe wrap, open utility holes.
cafeteria	5	73	31	587	ND	ND	14	Y # open: 0 # total: 12	Y ceiling	Y ceiling	Hallway DO, PF.

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Carbon Dioxide: < 600 ppm = preferred
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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

TABLE 2

Temperature, Relative Humidity and Moisture Test Results
Littleton, Shaker Lane School
January 12, 2006

Location	Temp (°F)	Relative Humidity (%)	Moisture Measurement*	Material/Comments
Outdoors	48	45		Mostly sunny, cool, westerly winds 5-10 mph
104	70	38	Center @ 18 feet - Low Center @ 16 feet - Low Center @ 14 feet - Low Center @ 12 feet - Low Center @ 10 feet - Low Center @ 8 feet - Low Center @ 6 feet - Low Center @ 4 feet - Low Center @ 2 feet - Low Center directly in front of univent - Low Right directly in front of univent – Low Left directly in front of univent – Low	Carpeting inspected and removed: no visible mold growth or associated odors, curved chalk line drawn by occupants indicating wet carpeting ~ 4-5 feet from univent
104	70	38	Bottom of wooden shelving – Low Wooden baseboard adjacent to univent at floor level - Low	Water staining on wooden baseboard
103	70	34	Center @ 18 feet - Low Center @ 16 feet - Low Center @ 14 feet - Low Center @ 12 feet - Low Center @ 10 feet - Low Center @ 8 feet - Low Center @ 6 feet - Low Center @ 4 feet - Low Center @ 2 feet - Low Center directly in front of univent - Low Right directly in front of univent – Low Left directly in front of univent – Low	Carpeting in non-effected room

TABLE 2

Temperature, Relative Humidity and Moisture Test Results
Littleton, Shaker Lane School
January 12, 2006

105	72	35	Center @ 18 feet - Low Center @ 16 feet - Low Center @ 14 feet - Low Center @ 12 feet - Low Center @ 10 feet - Low Center @ 8 feet - Low Center @ 6 feet - Low Center @ 4 feet - Low Center @ 2 feet - Low Center directly in front of univent - Low Right directly in front of univent – Low Left directly in front of univent – Low	Carpeting in non-effected room

* Low indicates normal moisture content